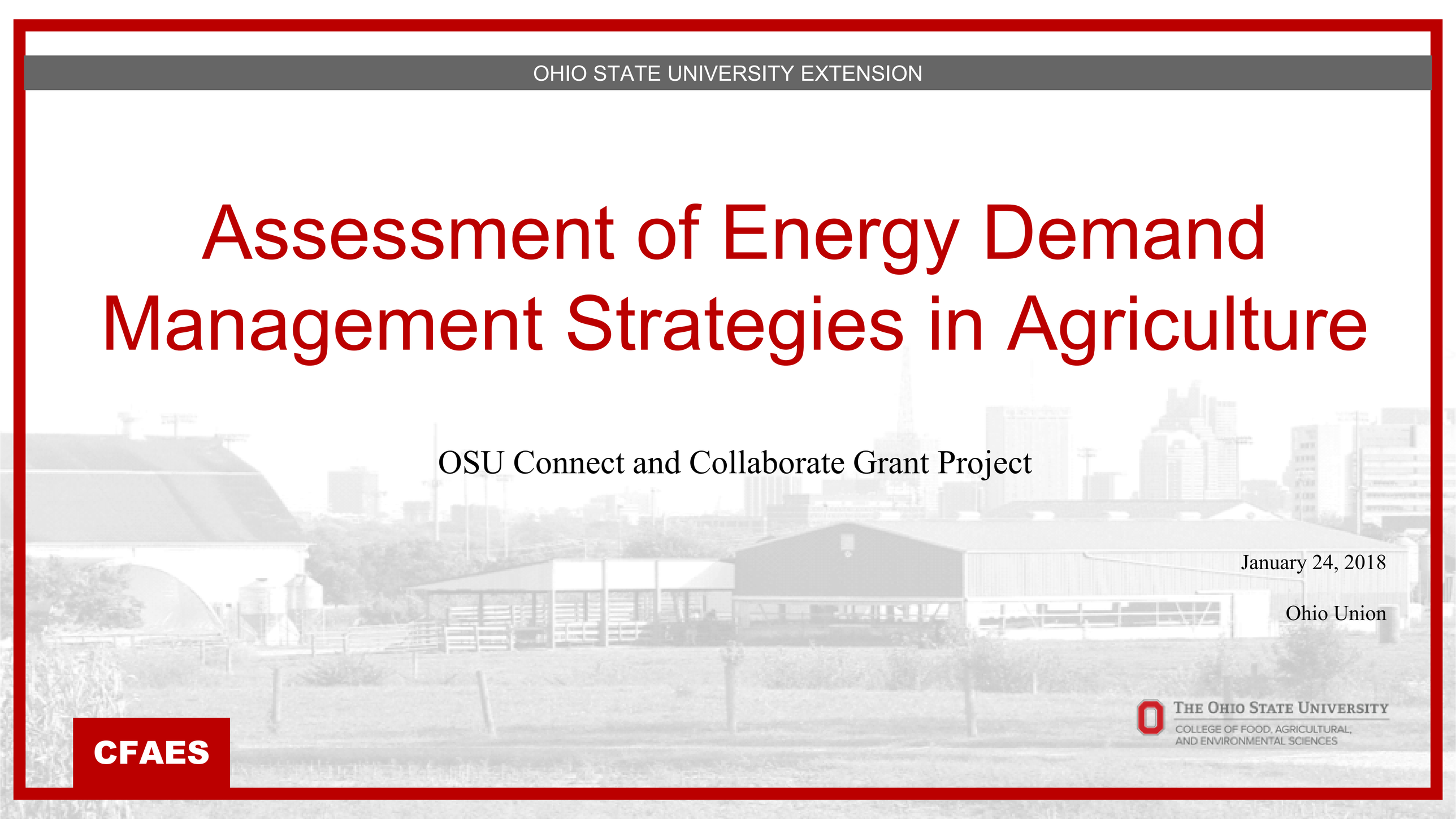
Assessment of Energy Demand Management Strategies in Agriculture

OSU Connect and Collaborate Grant Project

January 24, 2018

Ohio Union



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Learning Objectives

- Understand Your Electric Bill & Demand Charges
- Summarize Peak Demand Study Design
- Review Preliminary Peak Demand Data from Dairy Farm
- Recap the Lessons Learned, Recommendations, and Next Steps

Understanding Your Electric Bill & Demand Charges

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Energy in Agriculture

- In 2014, the agricultural sector consumed 1,714 trillion BTU of energy with electricity representing 17 percent of the total energy consumed in agriculture.
- Energy inputs are important to agriculture, as electricity costs average 1-6 percent of total expenses for farm businesses.
- In 2011 about three-fourths of U.S. farms had a profit margin of less than 10 percent, including roughly 61 percent with an operating profit margin of less than zero percent (USDA ERS, 2014). USDA ERS data shows that 2017-2018 farm income is projected to drop 12%.
- Higher energy expenses increase production costs, raise prices of agricultural products, and reduce farm income.

6% of a $50,000 Operational Budget is $3,000

6% of a $100,000 Operational Budget is $6,000

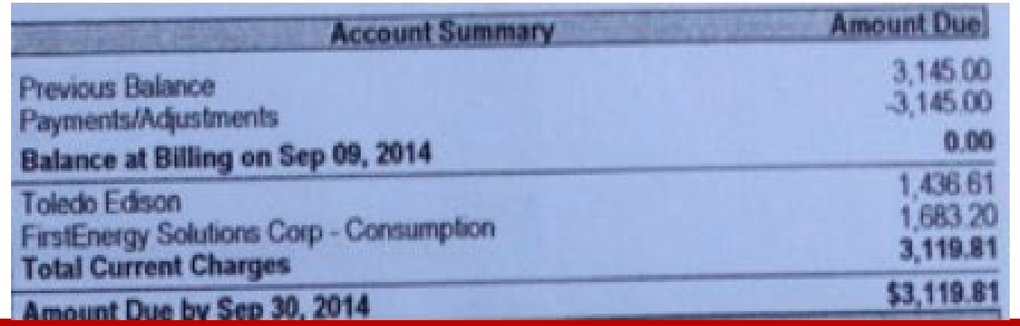
6% of a $500,000 Operational Budget is $30,000

Electric Bills on the Farm

- Agricultural operations are more sophisticated and automated with increasing electrical demands, requiring enhanced needs for high quality electric to power equipment. Due to increase electric usage, many farms are now on a commercial rate structure.

- Unlike residential rates, which are based primarily on total energy usage measured in **kilowatt-hours (kWh)**, commercial accounts are **also charged** for the highest peak demand usage spike over a short time period measured in **kilowatts (kW)**.

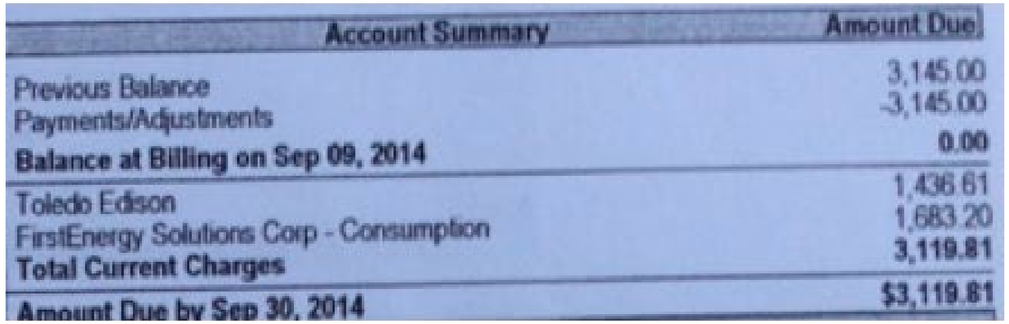
- The cost for providing electricity is determined by both energy used (kWh) and infrastructure required to meet your energy demand (kW). Energy and demand costs are lumped together for smaller users, but demand charges for larger businesses, including some farms, are charged separately. Users subject to demand charges can manage and lessen electric costs by knowing how these charges are assessed.



Account Summary	Amount Due
Previous Balance	3,145.00
Payments/Adjustments	-3,145.00
Balance at Billing on Sep 09, 2014	**0.00**
Toledo Edison	1,436.61
FirstEnergy Solutions Corp - Consumption	1,683.20
Total Current Charges	**3,119.81**
Amount Due by Sep 30, 2014	**$3,119.81**

$1,436 for demand charges on this farm, representing 46% of the total bill.

Potential Impact of Reducing Monthly Demand Charges



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$1,436 for demand charges on this farm, representing 46% of the total bill.

10% reduction of $1,436 demand charge is $146 savings

20% reduction of $1,436 demand charge is $287 savings

30% reduction of $1,436 demand charge is $430 savings

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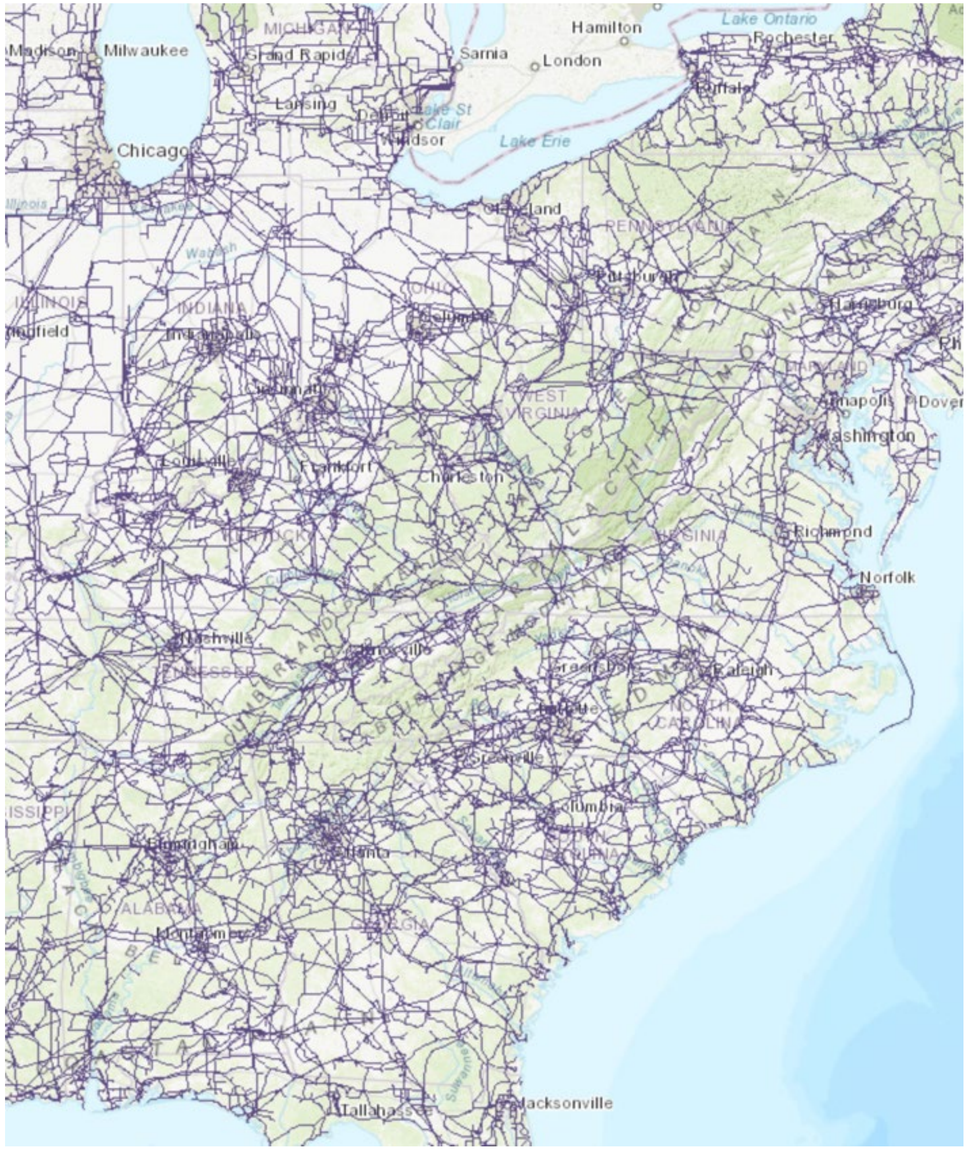
Introduction to Demand Charges

- Demand charges cover the electric utilities' costs of delivering a maximum level of energy to their customers. **Utilities' must maintain enough electrical generation and distribution infrastructure including substations, transformers, and wires to satisfy the highest spike in demand**, even if it occurs over a short period of time.

- Maintaining infrastructure to satisfy this peak demand is extremely expensive and demand charges help offset these costs.

- Assessing demand charges helps to allocate the associated cost to consumers that contribute to causing the inconsistent spike in usage and encourages users to reduce demand spikes in their load profile.



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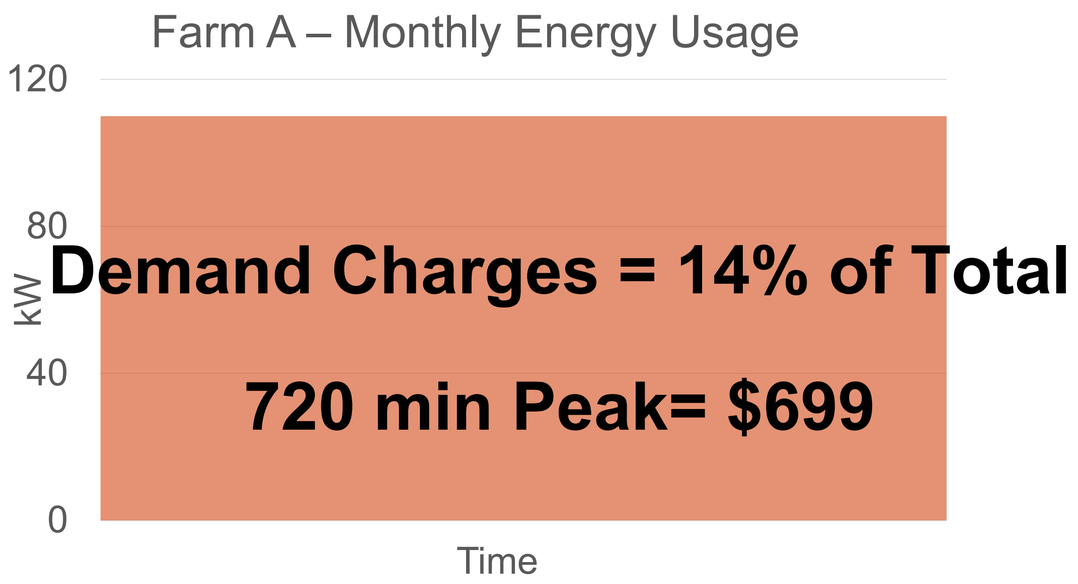
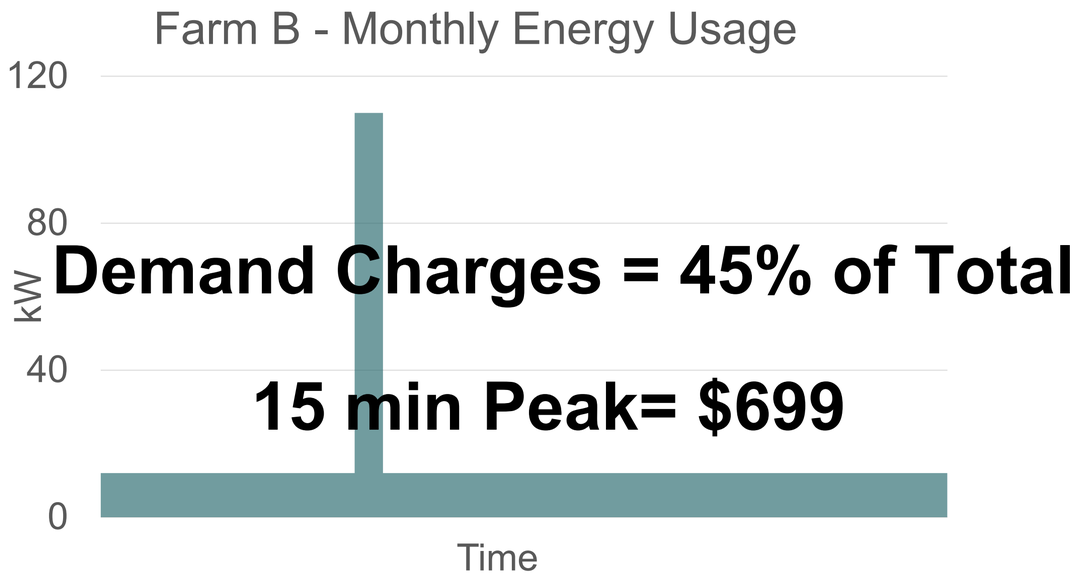
Example - Impact of Peak Demand Charges





	Usage Information	Rate	Amount
15 min Peak Demand	73 kW	$9.58	$699
Electric Usage	52,560 kWh	$0.0759	$3,989
Service Charge and Additional Riders (Fixed Fees)			$205
		Total	**$4,893**
		Total Cost Per kWh	**$0.093**

	Usage Information	Rate	Amount
15 min Peak Demand	73 kW	$9.58	$699
Electric Usage	8,440 kWh	$0.0759	$640
Service Charge and Additional Riders (Fixed Fees)			$205
		Total	**$1,544**
		Total Cost Per kWh	**$0.182**

Sample Electric Bill with Demand Charges

Summary of 15-Minute Monthly Peak Demand Charges	
Generation	$7.68
Transmission	$4.678
Distribution	$1.90
Total	$14.258
15 min Peak KW	x 73
15 min Demand Cost	$1,040

PJM High 5 Coincident Demand Rate	
Demand	$7.61
PJM 5 Demand - KW	x 57
PJM Demand Cost	$433

Total Demand Cost = $1,473

Billed Usage	20,680	73	57	
Generation & Trans:				
Demand - Monthly	$	7.68	73	$ 560.64
Demand - PJM 5	$	7.61	57	$ 433.77
Transmission	$	4.678	73	$ 341.49
Energy	$	0.00599	20,680	$ 123.87
Fuel	$	0.02701	20,680	$ 558.57
Total Generation & Transmission				$ 2,018.34
Distribution Service:				
Ser. Availability	$	80.00	1	$ 80.00
Demand	$	1.90	73	$ 138.70
Energy	$	0.0025	20,680	$ 51.70
Total Distribution				$ 270.40
Riders				$ 125.75
Total Energy Cost				$ 2,414.49

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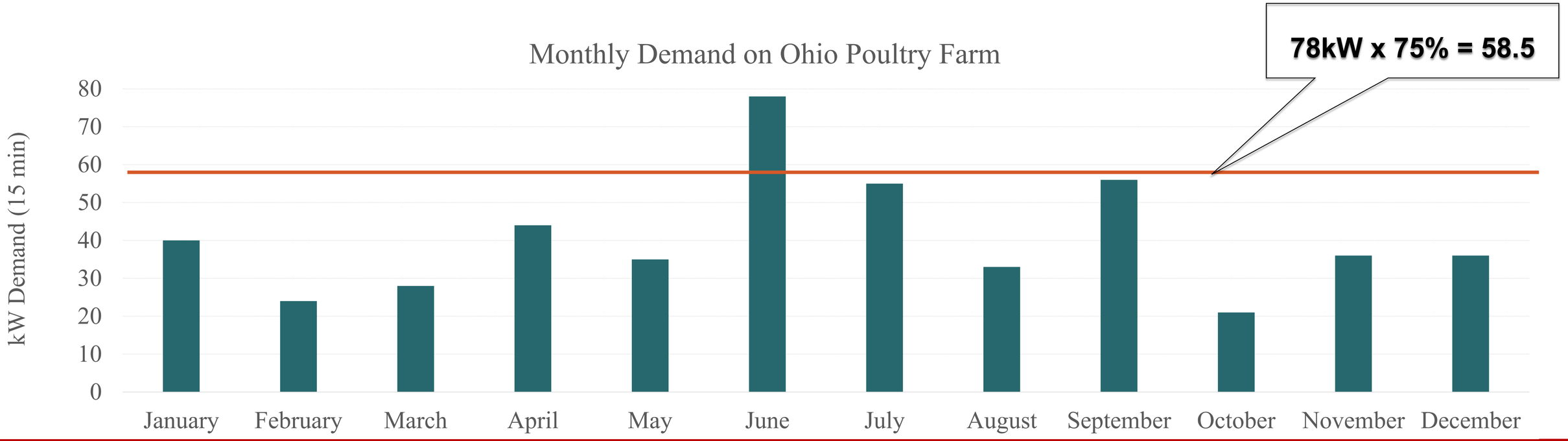
Ratchet Demand

- While each utility has unique language describing this process, it's common to find a clause that reads, "the minimum billing demand shall be the greatest of the following: (a) the maximum 15-minute integrated kW demand measured during the month, or (b) 75% of the highest kW demand similarly determined for any of the eleven (11) preceding months." In general terms this means 75% of the highest monthly demand experienced for the year becomes your minimum monthly demand for the next 11 months. Demand tariffs that include a "ratchet" provide opportunities for consumers to save money by better managing their usage patterns.



Peak Demand Study Design

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Connect and Collaborate Grant Project Overview: Assessment of Potential Energy Demand Management Strategies in Agriculture

The goal of this project is to **assess how peak electric demand affects agricultural facilities** and, in turn, the manner by which farmers can implement energy management plans, production strategies, and make investments in equipment to **minimize costs** and foster long-term sustainability.

- **Research Goal:** Generate empirical measures of data for peak demand and power quality in swine and dairy facilities, assess the economic impact, and explore potential tools and solutions.
- **Outreach and Engagement Goal:** Develop outreach and education materials to disseminate the project research findings to agricultural producers and stakeholders throughout Ohio and beyond.
- **Program Evaluation and Growth Goal:** Monitor project deliverables, evaluate program success, and explore options for the expansion and sustainability of the program.

OSU Connect and Collaborate Program

OSU Partners

- OSU CFAES, Ohio State University Extension, Community Development
- OSU CFAES, Ohio State University Extension, Agriculture and Natural Resources
- OSU CFAES, Ohio Agricultural Research and Development Center, ATI Dairy Farm
- OSU CFAES, Ohio Agricultural Research and Development Center, Western Ag Station
- OSU CFAES, Department of Food, Agricultural and Biological Engineering
- OSU College of Engineering, Electrical and Computer Engineering
- Ohio State University, Office of Energy and Environment

Farm Research Partners

- Isler Genetics
- Bernath Farms
- Specht Dairy Farms
- Harmony Dairy Farms

OSU Connect and Collaborate Program

Other Partnerships and Collaboration

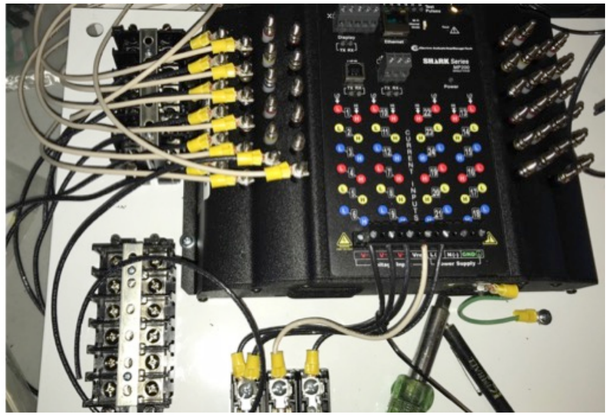
- Ron Cull, Electrical Engineer, NASA Lewis Research Center, Retired
- Ben Wilson, Manager, Power Delivery Engineering, Ohio Electric Cooperatives
- Bryan Humphreys, Executive Vice-President, Ohio Pork Council
- Barry McGraw, Product Commercialization & Animal Agriculture, Ohio Soybean Council
- Scott Higgins, CEO, Ohio Dairy Producers Association
- Cinch Munson, Director of Agriculture Business Development, National Propane Council
- Jason Watts, Renewable Energy Specialists, McNaughton McKay Electric
- Randy Monhemius, Program Specialist, U.S. Department of Agriculture Rural Development
- Cheryl Rice, Program Specialist, U.S. Department of Agriculture Natural Resources Conservation Service
- Dale Arnold, Director, Energy, Utility & Government Policy, Ohio Farm Bureau
- Chad Martin, Purdue University Extension, Renewable Energy Extension Specialist
- Charles Gould, Michigan State University Extension, Energy and Agriculture
- John Hay, University of Nebraska Extension, Energy Extension Specialist
- Eric Buchanan, University of Minnesota, Scientist, Renewable Energy

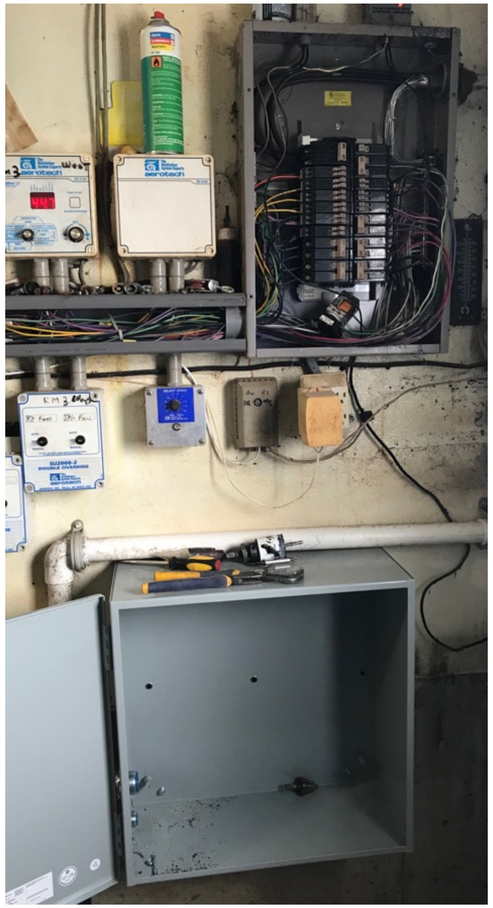
Funding Source Summary

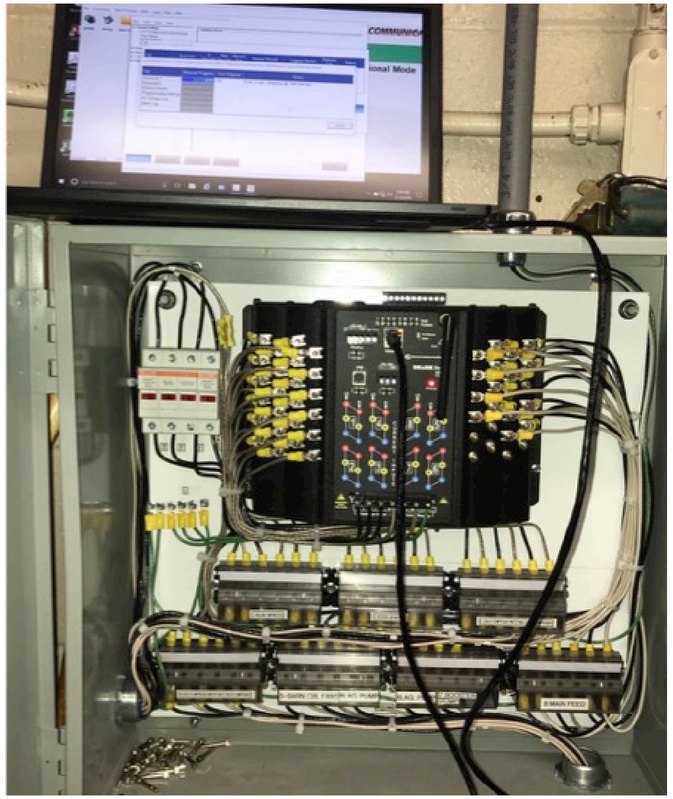
Amount ($)	Cash or In-Kind	College, Department or Unit, Campus
$73,500	Cash	OSU Office of Outreach and Engagement
$7,000	Cash	OSU CFAES, OSU Extension – Community Development
$7,000	Cash	OSU CFAES, OSU Extension – Agriculture and Natural Resources
$7,000	Cash	OSU CFAES, Ohio Agricultural Research and Development Center, Wooster Campus
$9,000	In-Kind	OSU CFAES, Ohio State University Extension, Columbus Campus
$2,000	In-Kind	OSU CFAES, Ohio Agricultural Research and Development Center, Wooster Campus
$2,000	In-Kind	OSU CFAES, Ohio Agricultural Research and Development Center, Western Agricultural Research Campus
$5000	In-Kind	OSU College of Engineering, Department of Electrical and Computer Engineering, Columbus Campus

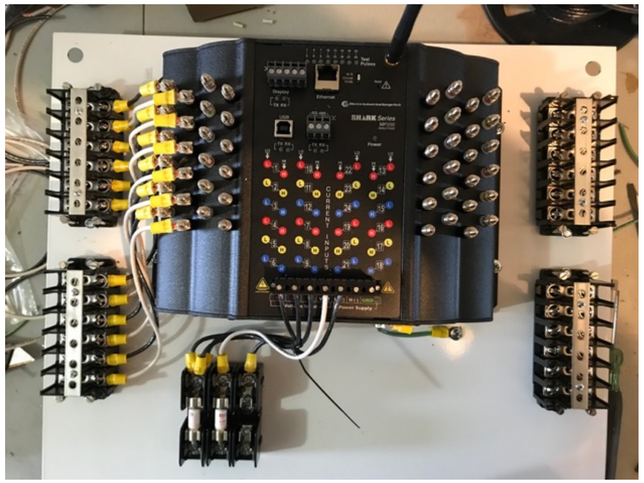
Equipment and Installation

Equipment and Installation









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Preliminary Data - Dairy Farm

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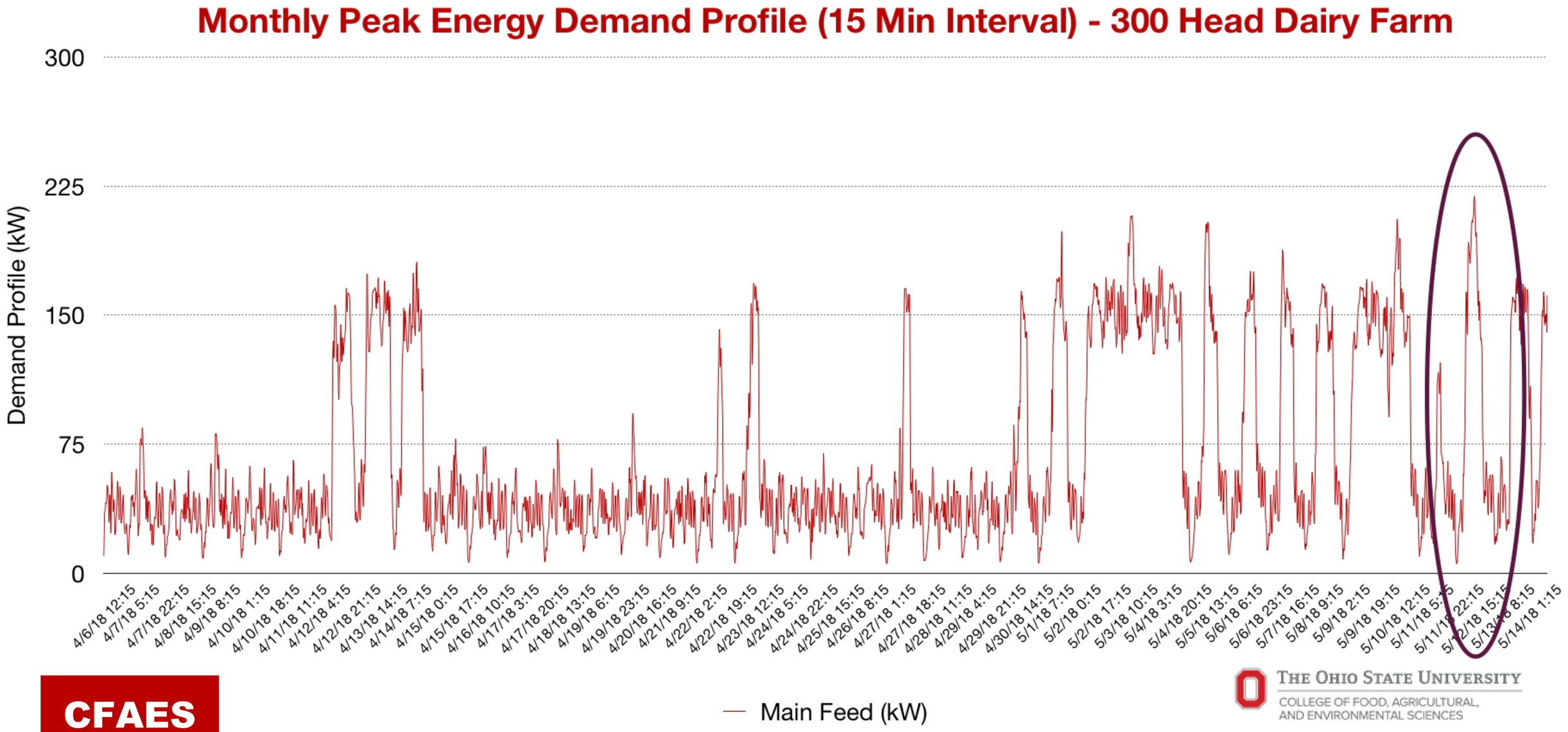

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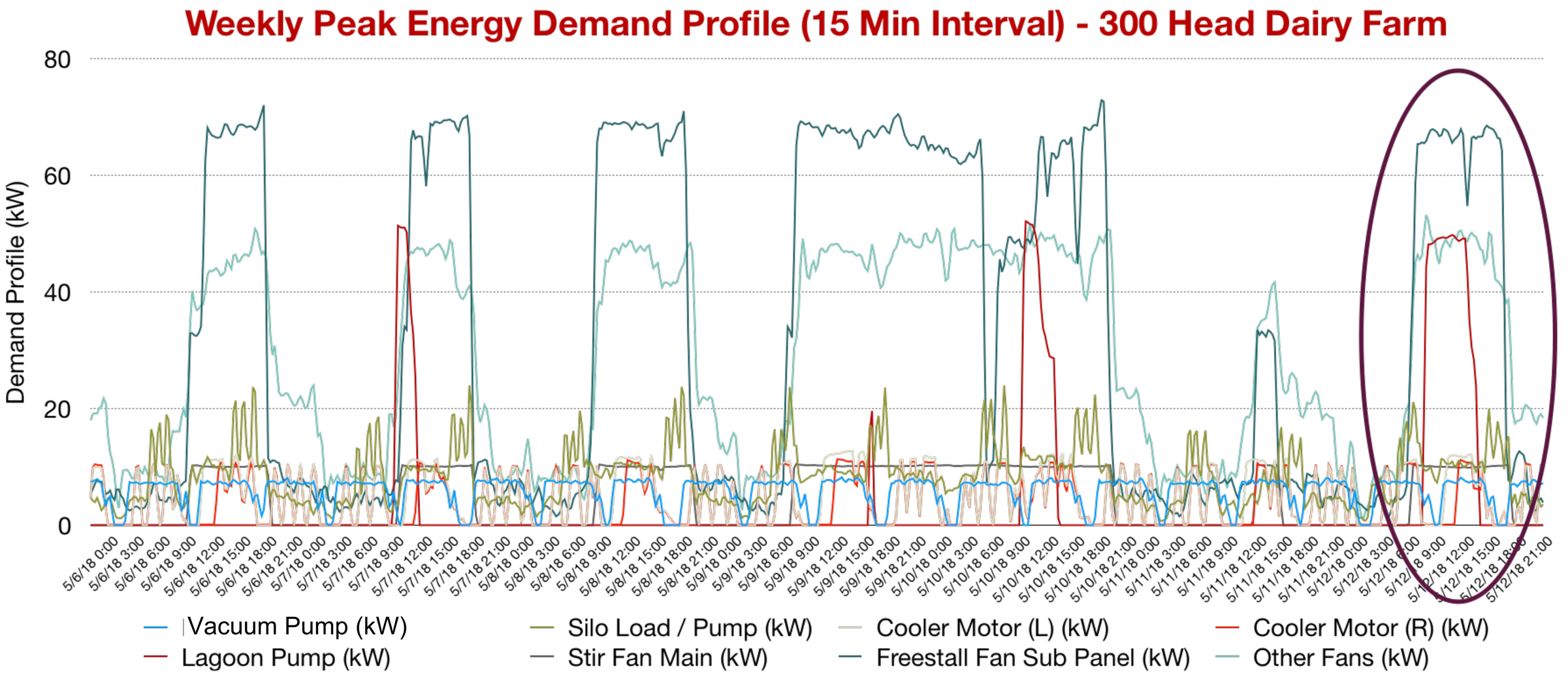

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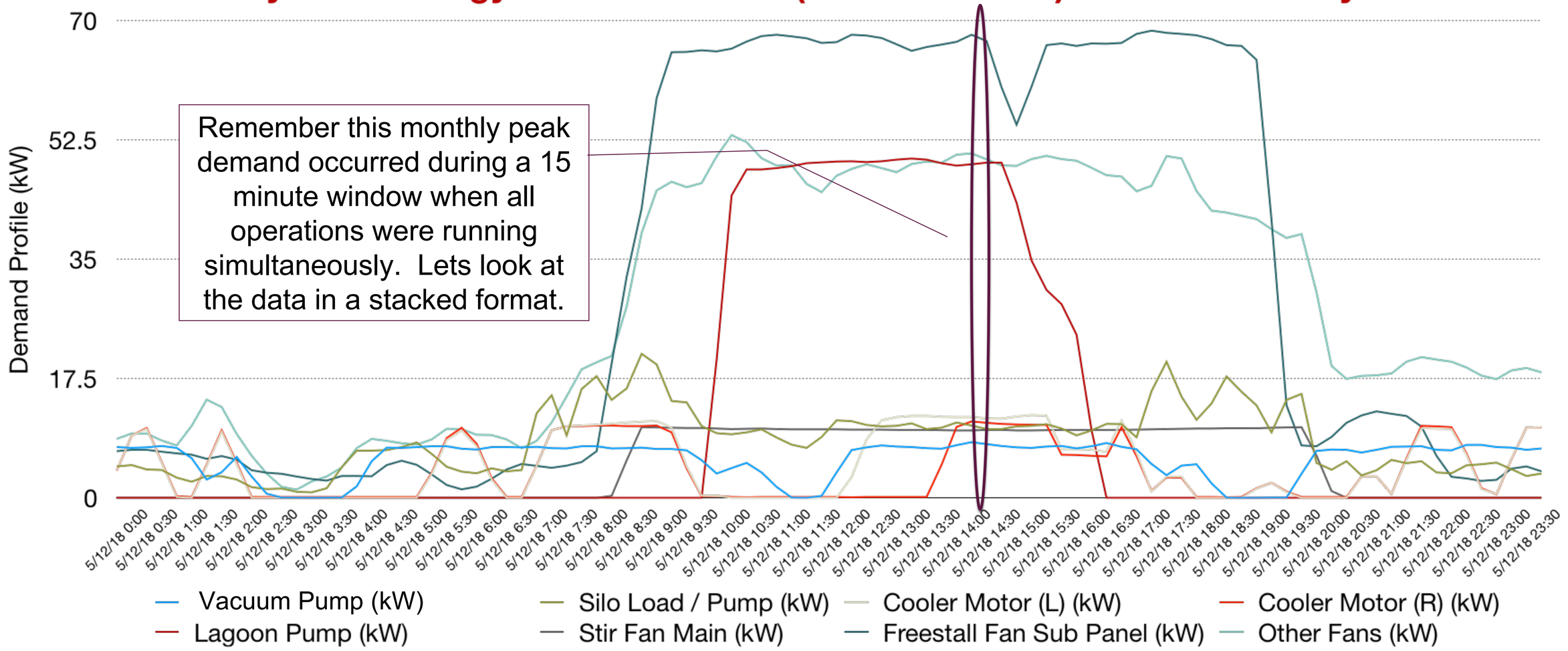
Daily Peak Energy Demand Profile (15 Min Interval) - 300 Head Dairy Farm



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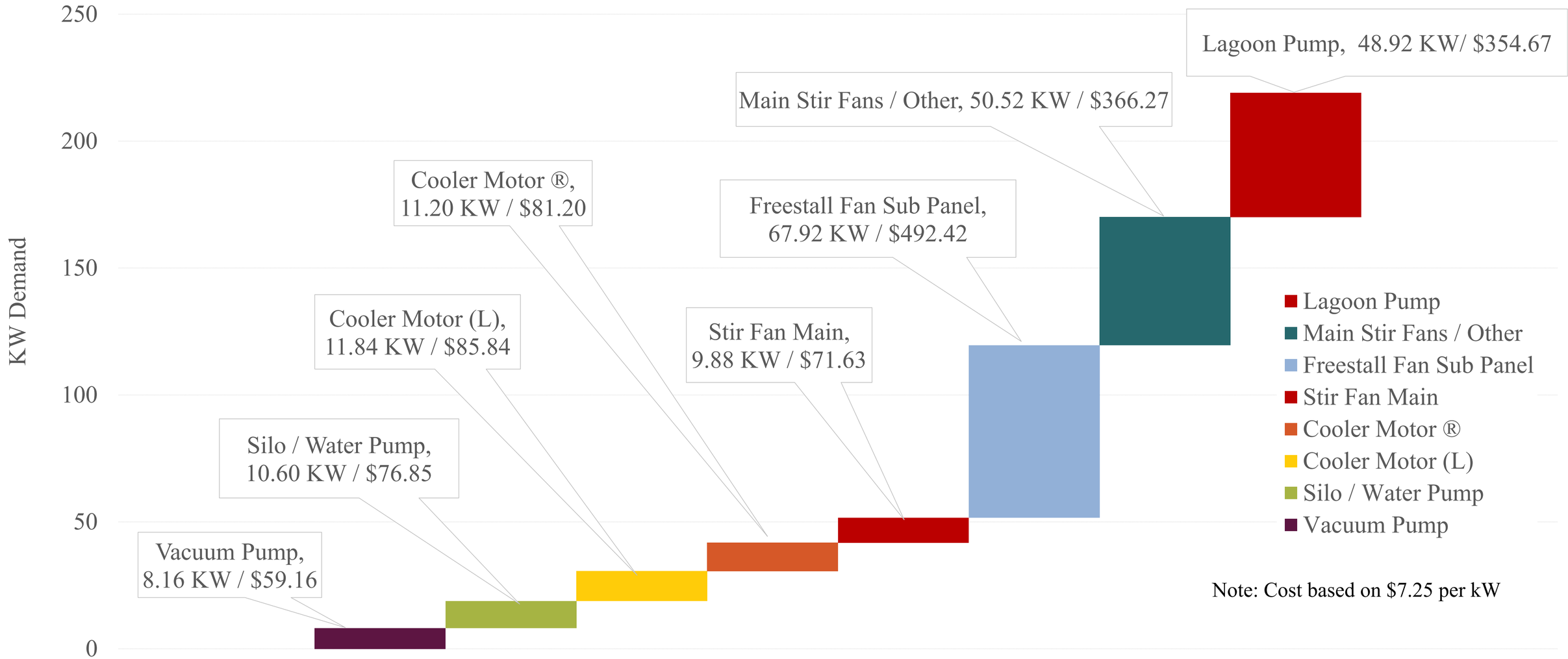
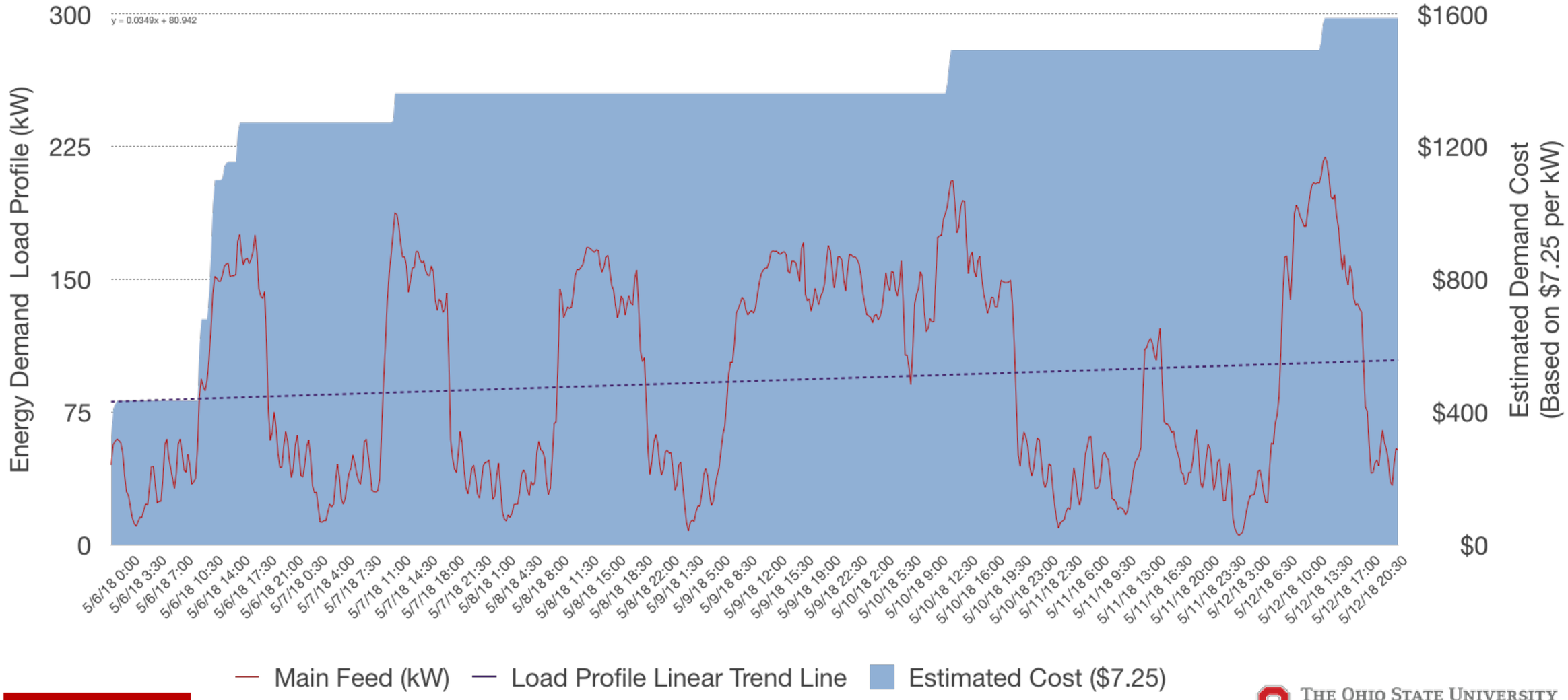
219 kW Monthly Demand Set on 5/12/18 @ 2:15 p.m.



Note: Cost based on $7.25 per kW

Weekly Peak Energy Demand Profile (15 Min Interval) - 300 Head Dairy Farm



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Outreach, Resources, and Next Steps

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Outreach and Education

OSU Extension Outreach

- Poster and handout materials at the OSU Extension Energy Tent at 2017 Farm Science Review
- OSU Extension Ask the Experts radio interview at the 2017 Farm Science Review
- USDA Radio interview discussing farm energy issues including solar and peak demand
- Presentation to the OSU Dairy Work Group

Outreach Resources

- Peak Demand Handout
- Research Poster
- Marketing Banner
- Radio Podcast

State and National Conferences

- Denman Undergraduate Research Forum - Columbus, OH
- Epsilon Sigma Phi (ESP) National Conference - Manhattan, Kansas
- National Association of County Agricultural Agents (NACAA) - Chattanooga, TN
- OSU Community Engagement Conference -Columbus, OH
- OSU Extension Annual Conference - Columbus, OH
- National Extension Energy Conference - Tampa, FL
- National Association of Community Development Extension Professionals - Asheville, NC (Pending)
- American Dairy Science Association - Cincinnati, OH (Pending)

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Exploring Partnerships Expansion and Growth

Phase 1: Expand Data Sample and Modeling

- Chicken Farms
- Egg Farms
- Turkey Farms
- Grain Handling
- Greenhouse
- Power Factor

Phase 2: Test Possible Solutions

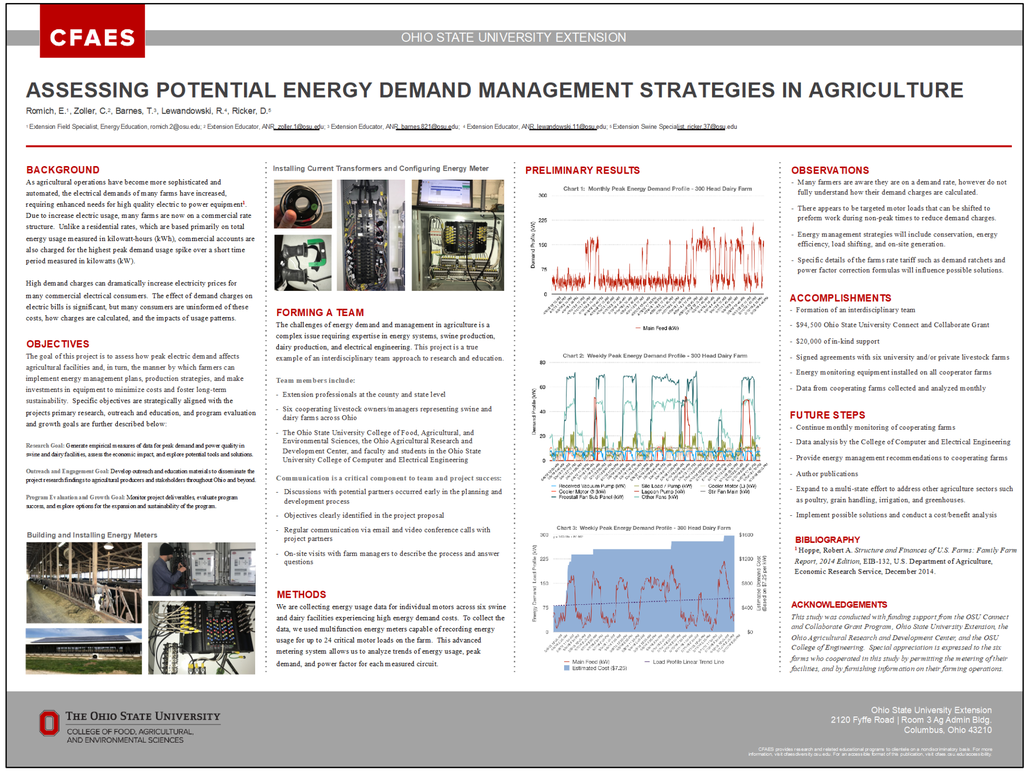
- Power Factor Correction
- Energy Efficiency
- Load Shifting
- Peak Shaving
- Renewable Energy & Storage

Phase 3: Building Solutions

- Use Data to Identify Building Deficiencies
- Model Potential Solutions for New Construction
  - Energy Savings
  - Economic Savings

Current and Future Resources

go.osu.edu/farmenergy



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OHIO STATE UNIVERSITY EXTENSION

ASSESSING POTENTIAL ENERGY DEMAND MANAGEMENT STRATEGIES IN AGRICULTURE

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BACKGROUND

As agricultural operations have become more sophisticated and automated, the electrical demands of many farms have increased, requiring enhanced needs for high quality electric to power equipment[1]. Due to increase electric usage, many farms are now on a commercial rate structure. Unlike a residential rates, which are based primarily on total energy usage measured in kilowatt-hours (kWh), commercial accounts are also charged for the highest peak demand usage spike over a short time period measured in kilowatts (kW).

High demand charges can dramatically increase electricity prices for many commercial electrical consumers. The effect of demand charges on electric bills is significant, but many consumers are uninformed of these costs, how charges are calculated, and the impacts of usage patterns.

OBJECTIVES

The goal of this project is to assess how peak electric demand affects agricultural facilities and, in turn, the manner by which farmers can implement energy management plans, production strategies, and make investments in equipment to minimize costs and foster long-term sustainability. Specific objectives are strategically aligned with the projects primary research, outreach and education, and program evaluation and growth goals are further described below:

Research Goal: Generate empirical measures of data for peak demand and power quality in swine and dairy facilities, assess the economic impact, and explore potential tools and solutions.

Outreach and Engagement Goal: Develop outreach and education material to disseminate the project research findings to agricultural producers and stakeholders throughout Ohio and beyond.

Program Evaluation and Growth Goal: Monitor project deliverables, evaluate program success, and explore options for the expansion and sustainability of the program.

Building and Installing Energy Meters

Installing Current Transformers and Configuring Energy Meter

FORMING A TEAM

The challenges of energy demand and management in agriculture is a complex issue requiring expertise in energy systems, swine production, dairy production, and electrical engineering. This project is a true example of an interdisciplinary team approach to research and education.

Team members include:

- Extension professionals at the county and state level
- Six cooperating livestock owners/managers representing swine and dairy farms across Ohio
- The Ohio State University College of Food, Agricultural, and Environmental Sciences, the Ohio Agricultural Research and Development Center, and faculty and students in the Ohio State University College of Computer and Electrical Engineering

Communication is a critical component to team and project success:

- Discussions with potential partners occurred early in the planning and development process
- Objectives clearly identified in the project proposal
- Regular communication via email and video conference calls with project partners
- On-site visits with farm managers to describe the process and answer questions

METHODS

We are collecting energy usage data for individual motors across six swine and dairy facilities experiencing high energy demand costs. To collect the data, we used multifunction energy meters capable of recording energy usage for up to 24 critical motor loads on the farm. This advanced metering system allows us to analyze trends of energy usage, peak demand, and power factor for each measured circuit.

PRELIMINARY RESULTS

Chart 1: Monthly Peak Energy Demand Profile - 300 Head Dairy Farm

Chart 2: Weekly Peak Energy Demand Profile - 300 Head Dairy Farm

Chart 3: Weekly Peak Energy Demand Profile - 300 Head Dairy Farm

OBSERVATIONS

- Many farmers are aware they are on a demand rate, however do not fully understand how their demand charges are calculated.
- There appears to be targeted motor loads that can be shifted to preform work during non-peak times to reduce demand charges.
- Energy management strategies will include conservation, energy efficiency, load shifting, and on-site generation.
- Specific details of the farms rate tariff such as demand ratchets and power factor correction formulas will influence possible solutions.

ACCOMPLISHMENTS

- Formation of an interdisciplinary team
- $94,500 Ohio State University Connect and Collaborate Grant
- $20,000 of in-kind support
- Signed agreements with six university and/or private livestock farms
- Energy monitoring equipment installed on all cooperator farms
- Data from cooperating farms collected and analyzed monthly

FUTURE STEPS

- Continue monthly monitoring of cooperating farms
- Data analysis by the College of Computer and Electrical Engineering
- Provide energy management recommendations to cooperating farms
- Author publications
- Expand to a multi-state effort to address other agriculture sectors such as poultry, grain handling, irrigation, and greenhouses.
- Implement possible solutions and conduct a cost/benefit analysis

BIBLIOGRAPHY

[1] Hoppe, Robert A. *Structure and Finances of U.S. Farms: Family Farm Report, 2014 Edition*, EIB-132, U.S. Department of Agriculture, Economic Research Service, December 2014.

ACKNOWLEDGEMENTS

This study was conducted with funding support from the OSU Connect and Collaborate Grant Program, Ohio State University Extension, the Ohio Agricultural Research and Development Center, and the OSU College of Engineering. Special appreciation is expressed to the six farms who cooperated in this study by permitting the metering of their facilities, and by furnishing information on their farming operations.

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